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AERONAUTICS

THIRD ANNUAL REPORT

OF THE

NATIONAL ADVISORY COMMITTEE

FOR AERONAUTICS

1917



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To be retained in
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Memorial Aeronautical

~~455~~
WASHINGTON.

GOVERNMENT PRINTING OFFICE

1918

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¹ Reports 1 to 7, inclusive, published in first annual report; reports 8 to 12, inclusive, published in second annual report.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

MUNSEY BUILDING, WASHINGTON, D. C.

Dr. WILLIAM F. DURAND, *Chairman*,
Munsey Building, Washington, D. C.
Dr. S. W. STRATTON, *Secretary*,
Bureau of Standards, Washington, D. C.
Dr. JOSEPH S. AMES,
Johns Hopkins University, Baltimore, Md.
Lieut. Col. V. E. CLARK, S. C.,
Signal Corps, Experimental Station, Dayton, Ohio.
Prof. JOHN F. HAYFORD,
Northwestern University, Evanston, Ill.
Prof. CHARLES F. MARVIN,
Chief United States Weather Bureau.
Hon. BYRON R. NEWTON,
Assistant Secretary of the Treasury, Treasury Department.
Dr. MICHAEL I. PUPIN,
Columbia University, New York, N. Y.
Maj. Gen. GEORGE O. SQUIER,
Chief Signal Officer of the Army, War Department.
Rear Admiral D. W. TAYLOR,
Chief Constructor, United States Navy, Navy Department.
Lieut. Commander J. H. TOWERS, United States Navy,
Office of Operations, Navy Department.
Dr. CHARLES D. WALCOTT,
Secretary Smithsonian Institution.

EXECUTIVE COMMITTEE.

Dr. CHARLES D. WALCOTT, *Chairman*.
Dr. S. W. STRATTON, *Secretary*.

Dr. JOSEPH S. AMES.
Dr. W. F. DURAND.
Prof. CHARLES F. MARVIN.

Dr. MICHAEL I. PUPIN.
Maj. Gen. GEORGE O. SQUIER, U. S. Army.
Rear Admiral D. W. TAYLOR, U. S. Navy.

MESSAGE OF THE PRESIDENT.

To the Senate and House of Representatives:

I transmit herewith for the consideration of the Congress, the Third Annual Report of the National Advisory Committee for Aeronautics, including a statement of the expenditures to June 30, 1917.

The estimates of the committee, together with its plans for enlarged activities contemplated through its laboratories and scientific staff at Langley Field, outlined in the closing paragraphs of the report, have my hearty approval.

The attention of the Congress is also invited to the request of the committee that the appendixes to its report be published with the report.

WOODROW WILSON.

THE WHITE HOUSE, December 7, 1917.

LETTER OF SUBMITTAL.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS,
MUNSEY BUILDING,
Washington, D. C., December 3, 1917.

The PRESIDENT:

In compliance with the provisions of the act of Congress approved March 3, 1915 (naval appropriation act, Public, No. 273, 63d Cong.), the National Advisory Committee for Aeronautics has the honor to submit herewith its third annual report, including a statement of the expenditures to June 30, 1917.

In order to carry out its purposes and objects, as defined in the act of March 3, 1915, the committee submits herewith certain recommendations and an estimate of expenses for the fiscal year ending June 30, 1919.

Attention is invited to the appendixes of the committee's report, and it is requested that they be published with the report of the committee as a public document.

The committee desires especially to draw to your attention the closing paragraphs of its report and trusts that the enlarged activities which it is contemplating through its laboratories and scientific staff at Langley Field may meet with your approval.

Very respectfully.

W. F. DURAND, *Chairman.*

THIRD ANNUAL REPORT OF THE NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS,
MUNSEY BUILDING,
Washington, D. C., December 3, 1917.

To the Congress:

In accordance with the provisions of the act of Congress approved March 3, 1915, establishing the National Advisory Committee for Aeronautics, the committee submits herewith its third annual report.

This report reviews the activities of the committee during the past year, the work accomplished in the study of scientific problems, the assistance rendered by the committee in connection with aerial preparedness for war and in the development of the aircraft industry to meet the demands of the Government, and contains a statement of expenditures, estimates for the fiscal year 1919, and certain recommendations for the consideration of Congress. Technical reports covering the various subjects under investigation during the past year are submitted as appendixes.

THE NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

The National Advisory Committee for Aeronautics was established by Congress by act approved March 3, 1915. Under the law the committee is charged with the supervision and direction of the scientific study of the problems of flight with a view to their practical solution, the determination of the problems which should be experimentally attacked, their investigation and application to practical aeronautics. The committee is also authorized to direct and conduct research and experiment in aeronautics in such laboratory or laboratories, either in whole or in part, as may be placed under its direction.

The committee has 12 members appointed by the President. As authorized by Congress, the personnel of the committee consists of 2 members from the War Department, from the office in charge of military aeronautics; 2 members from the Navy Department, from the office in charge of naval aeronautics; a representative each of the Smithsonian Institution, of the United States Weather Bureau, and of the United States Bureau of Standards; and not more than 5 additional persons acquainted with the needs of aeronautical science, either civil or military, or skilled in aeronautical engineering or its allied sciences.

During the past year the two naval members of the committee, Capt. Mark L. Bristol, United States Navy, and Naval Constructor Holden C. Richardson, United States Navy, the latter being also secretary of the committee, resigned on account of transfer to duty away from Washington; and Brig. Gen. George B. Scriven, United States Army, resigned on account of retirement. To fill the vacan-

cies thus occasioned, the President appointed the following members: Rear Admiral D. W. Taylor, Chief Constructor United States Navy; Lieut. Commander J. H. Towers, United States Navy; and Lieut. Col. V. E. Clark, Signal Corps. Dr. S. W. Stratton succeeded Naval Constructor Richardson as secretary.

The organization of the Advisory Committee as of October 4, 1917, the date of the annual meeting, is as follows:

Dr. William F. Durand, chairman.

Dr. S. W. Stratton, secretary.

Dr. Charles D. Walcott, chairman executive committee.

Dr. Joseph S. Ames.

Lieut. Col. V. E. Clark, United States Army.

Prof. John F. Hayford.

Prof. Charles F. Marvin.

Hon. Byron R. Newton.

Dr. Michael I. Pupin.

Maj. Gen. George O. Squier, United States Army.

Rear Admiral David W. Taylor, United States Navy.

Lieut. Commander John H. Towers, United States Navy.

The annual meetings of the Advisory Committee are held in October and the semiannual meetings in April. The present report includes the activities of the committee between the annual meeting held on October 5, 1916, and that held on October 4, 1917.

AMENDMENTS TO REGULATIONS.

At the semiannual meeting on April 19, 1917, the regulations were amended to provide:

That the secretary be not ex officio member and secretary of the executive committee as had formerly been the case, but that the executive committee elect its secretary by ballot to serve for one year.

That the executive committee, in addition to the seven members elected by ballot, should include further any member of the Advisory Committee not otherwise a member of the executive committee but resident in or near Washington and giving his time wholly or chiefly to the special work of the committee.

That the members and employees of the Advisory Committee and of all subcommittees may be allowed traveling expenses and \$4 per diem in lieu of subsistence while traveling under orders of the committee on official business.

That the executive committee shall appoint a special disbursing agent for such funds as may be appropriated for the use of the Advisory Committee and that the chairman, or acting chairman, of the executive committee shall approve all accounts for the disbursement of funds.

That amendments may be made by a two-thirds vote by letter ballot or at a special meeting, subject to approval by the President, and need not necessarily wait upon stated meetings for consideration.

THE EXECUTIVE COMMITTEE.

For carrying out the work of the Advisory Committee the regulations provide for the election annually of an executive committee, to consist of seven members, and to include further any member of the Advisory Committee not otherwise a member of the executive committee, but resident in or near Washington and giving his time wholly or chiefly to the special work of the committee. The executive committee, as organized on October 9, 1917, is as follows:

Dr. Charles D. Walcott, chairman, Secretary Smithsonian Institution.

Dr. S. W. Stratton, secretary, Director Bureau of Standards.

Dr. Joseph S. Ames, physicist, Johns Hopkins University.

Prof. Charles F. Marvin, Chief United States Weather Bureau.

Dr. Michael I. Pupin, physicist and electrical engineer, Columbia University.

Maj. Gen. George O. Squier, Chief Signal Officer United States Army.

Rear Admiral D. W. Taylor, Chief Constructor United States Navy.

Dr. W. F. Durand, chairman, National Advisory Committee for Aeronautics, additional member.

The executive committee, in accordance with the general instructions of the Advisory Committee, controls the administration of the affairs of the committee and exercises general supervision over all arrangements for research and other matters undertaken or promoted by the Advisory Committee. It keeps written records of all transactions and expenditures and submits an annual report to the Advisory Committee, the details of which furnish the material for the present report.

The executive committee held regular monthly meetings throughout the year, and in addition, held 13 special meetings on the following dates:

Regular meetings.—October 12, 1916; November 9, 1916; December 7, 1916; January 11, 1917; February 10, 1917; March 8, 1917; April 12, 1917; May 10, 1917; June 14, 1917; July 12, 1917; August 9, 1917; September 13, 1917.

Special meetings.—October 9, 1916; November 23, 1916; February 1, 1917; February 3, 1917; February 4, 1917; March 22, 1917; March 29, 1917; April 5, 1917; April 10, 1917; April 23, 1917; May 26, 1917; September 27, 1917; October 2, 1917.

The committee has organized the necessary small clerical and technical staffs. All work is performed under the personal supervision of one or more of the officers of the committee. An assistant secretary, who also serves as special disbursing agent, has charge of the office, records, and property of the committee.

SUBCOMMITTEES.

The following subcommittees organized under the executive committee have greatly facilitated the work of the committee during the past year. Under provision of the regulations for the conduct of the work of the committee the membership of subcommittees is not limited to members of the Advisory Committee. The committees marked with an asterisk have been superseded or discharged:

*AERIAL MAIL SERVICE:

Maj. Gen. George O. Squier, United States Army, chairman.

Prof. Charles F. Marvin.

Dr. S. W. Stratton.

Lieut. Col. V. E. Clark, United States Army.

Lieut. Commander J. H. Towers, United States Navy.

AERO TORPEDOES:

Lieut. Commander J. H. Towers, United States Navy, chairman.

Lieut. Col. V. E. Clark, United States Army.

AIRCRAFT COMMUNICATIONS:

Dr. Michael I. Pupin, chairman.

Dr. Joseph S. Ames.

Dr. S. W. Stratton.

Dr. E. B. Ross.

AIRPLANE MAPPING COMMITTEE:

Maj. Gen. George O. Squier, United States Army, chairman.
 Dr. Charles D. Walcott.
 Capt. J. W. Bagley, Engineer Officers' Reserve Corps.
 Carl G. Fisher.

BIBLIOGRAPHY OF AERONAUTICS:

Prof. Charles F. Marvin, chairman.
 Dr. Joseph S. Ames.

BUILDINGS, LABORATORIES, AND EQUIPMENT:

Dr. S. W. Stratton, chairman.
 Dr. Joseph S. Ames.
 Dr. W. F. Durand.
 Lieut. Col. V. E. Clark, United States Army.
 Lieut. Commander J. H. Towers, United States Navy.

CIVIL AERIAL TRANSPORT:

Dr. W. F. Durand, chairman.
 Dr. S. W. Stratton.
 Prof. Charles F. Marvin.
 Lieut. Col. V. E. Clark, United States Army.
 Lieut. Commander J. H. Towers, United States Navy.

DESIGN, CONSTRUCTION, AND NAVIGATION OF AIRCRAFT:

Maj. Gen. George O. Squier, United States Army, chairman.
 Dr. Joseph S. Ames.
 Lieut. Commander J. H. Towers, United States Navy.
 Lieut. Col. V. E. Clark, United States Army.
 Dr. A. F. Zahm, secretary.
 Frederick Alger.
 M. D. Hersey.
 J. H. Nelson.

Aeronautic instruments—

Dr. Joseph S. Ames, chairman.
 Commander W. T. Jewell, United States Navy.
 M. D. Hersey.
 Maj. C. E. Mendenhall, Signal Corps.
 Dr. Lyman Briggs.

EDITORIAL:

Dr. Joseph S. Ames, chairman.
 Dr. S. W. Stratton.
 Dr. W. F. Durand.

***FOREIGN REPRESENTATIVES:**

Dr. Charles D. Walcott, chairman.
 Maj. Gen. George O. Squier, United States Army.
 Rear Admiral D. W. Taylor, United States Navy.

FREE FLIGHT TESTS:

Prof. John F. Hayford, chairman.
 Dr. W. F. Durand.
 Dr. S. W. Stratton.
 Lieut. Col. V. E. Clark, United States Army.
 Prof. A. Klemin.
 Dr. Lyman Briggs.
 Dr. A. F. Zahm.
 Lieut. G. P. Thomson, R. F. C.

GOVERNMENTAL RELATIONS:

Dr. Charles D. Walcott, chairman.
 Dr. S. W. Stratton.

HELICOPTER, or DIRECT-LIFT AIRCRAFT:

Dr. W. F. Durand, chairman.
 Dr. Michael I. Pupin.
 M. B. Sellers.
 Dr. A. F. Zahm.
 Prof. E. B. Wilson.

NOMENCLATURE FOR AERONAUTICS:

Dr. Joseph S. Ames, chairman.
 Dr. S. W. Stratton.
 Maj. Gen. George O. Squier, United States Army.
 Capt. Mark L. Bristol, United States Navy.
 Naval Constructor H. C. Richardson, United States Navy.

***PATENTS:**

Dr. Charles D. Walcott, chairman.
Dr. S. W. Stratton.
Lieut. Commander J. H. Towers, United States Navy.
S. D. Waldon.
Frederick P. Fish.
W. Benton Crisp.
Dr. W. F. Durand.

***POLICY:**

Prof. John F. Hayford, chairman.
Dr. Joseph S. Ames.
Dr. S. W. Stratton.

POWER PLANTS:

Dr. S. W. Stratton, chairman.
Maj. Gen. George O. Squier, United States Army.
Dr. W. F. Durand.
Lieut. Commander J. H. Towers, United States Navy.
Dr. H. C. Dickinson, secretary.
Prof. J. C. Riley.
Prof. E. Newcomb.
Lieut. Commander A. K. Atkins, United States Navy.

***QUARTERS:**

Dr. S. W. Stratton, chairman.
Maj. Gen. George O. Squier, United States Army.

***RADIATOR DESIGN:**

Naval Constructor H. C. Richardson, United States Navy, chairman.
Dr. S. W. Stratton.
Maj. Henry Souther.

RELATION OF THE ATMOSPHERE TO AERONAUTICS:

Prof. Charles F. Marvin, chairman.
Dr. Joseph S. Ames.
Prof. John F. Hayford.
Lieut. Commander J. H. Towers, United States Navy.

***SITE FOR EXPERIMENTAL FIELD:**

Dr. Charles D. Walcott, chairman.
Prof. Charles F. Marvin.
Dr. S. W. Stratton.

SPECIAL COMMITTEE ON ENGINEERING PROBLEMS:

Dr. W. F. Durand, chairman.
Dr. S. W. Stratton.
Dr. A. F. Zahm.
Dr. H. C. Dickinson.
Herbert Chase.
Grover C. Loening.

STANDARDIZATION AND INVESTIGATION OF MATERIALS:

Dr. S. W. Stratton, chairman.
Dr. Joseph S. Ames.
Maj. Gen. George O. Squier, United States Army.
Dr. W. F. Durand.
Prof. John F. Hayford.
Naval Constructor J. C. Hunsaker, United States Navy.
J. H. Nelson.
E. D. Walen.

Light alloys—

Dr. G. K. Burgess, chairman.
Naval Constructor J. C. Hunsaker, United States Navy.
Charles M. Manly.
E. Blough.
Z. Jeffries.
Prof. O. H. Mathewson.

STEEL CONSTRUCTION FOR AIRCRAFT:

Dr. W. F. Durand, chairman.
Dr. S. W. Stratton.
Dr. A. F. Zahm.
F. G. Diffin.
W. B. Stout.
J. H. Nelson.

STEEL CONSTRUCTION FOR AIRCRAFT—Continued.

H. L. Whittemore.

J. W. Smith.

Jesse Coates.

QUARTERS FOR COMMITTEE.

The office and headquarters of the committee are located in rooms 515-519 Munsey Building, Washington, D. C. The technical work of the committee, performed largely by or under the direction of the various subcommittees, is carried out in various laboratories and shops belonging to the Government and universities of learning whose facilities for scientific research are at the disposal of the Government.

To carry on the highly scientific and special investigations contemplated in the act establishing the committee, and which have, since the outbreak of the war, assumed greater importance, and for which facilities do not already exist, or exist in only a limited degree, the committee has contracted for a research laboratory to be erected on the Signal Corps Experimental Station, Langley Field, Hampton, Va. The dimensions of the research laboratory building are 123 by 52 feet. The building is two stories in height, constructed of red brick, with limestone belt courses, coping, and main entrances, including ornamental pediment. In the west half of the building, on the first floor, it is planned to locate a well-equipped machine shop and structural testing laboratory, with a pattern shop directly above the laboratory on the second floor. In the east half of the building, on both floors, it is planned to locate the executive offices, drafting rooms, photographic, physical, and chemical laboratories. The plot of ground on which the building is placed was assigned to the committee by the War Department and will allow the addition of two wings of the same size as the present building. There is also room for two wind tunnels which are contemplated in the near future. An engine test shed will be placed in a convenient location. Authority for the construction of small additional buildings necessary in connection with the laboratory was contained in the urgent deficiency act approved October 6, 1917.

ACTIVITIES OF THE COMMITTEE IN CONNECTION WITH PREPARATION OF AN AERIAL FLEET FOR WAR.

In the latter part of March, 1917, when war with Germany seemed imminent, the committee, in conference with United States military and naval officers and manufacturers of aircraft, reviewed the condition of the aeronautic industry, the facilities then existing in this country for meeting the requirements of the Government, the possibilities of adequate expansion, and the then patent situation and its influence on the aeronautic industry.

A subcommittee was appointed to cooperate with representatives of aircraft manufacturers and to investigate all problems entering into the quantity production of aircraft for the Government. After careful study of the conditions then existing, the Advisory Committee submitted recommendations to the War and Navy Departments for increasing the quantity production of aircraft and urging the adoption of a continuing program of manufacture for the next three years.

In early April the chairman of the executive committee conferred with the Secretary of the Navy and the Secretary of War as to the best method to obtain the most efficient results in the development of aviation and the supply of aircraft for military and naval purposes, stating that the Advisory Committee deemed it desirable to create an aeronautical production board with a civilian head, but not a distinct Government department. This met the informal approval of the two Secretaries, and after a thorough study of the problem and in the light of the history of the air services of England and France since the beginning of the war in Europe, the committee recommended to the Council of National Defense that a board be appointed by the Council of National Defense, with the approval of the Secretary of War and the Secretary of the Navy, to be known as the aircraft production board, whose duties would be to consider and deal with the problems arising in connection with the quantity production of aircraft in the United States for military purposes. The committee had previously undertaken a census of the production facilities of manufacturers of aircraft and aeronautic engines, and this information was made available to the aircraft production board at the beginning of its work in April. The Advisory Committee further recommended that the Secretary of War and the Secretary of the Navy appoint a joint technical board of the Army and Navy for determining specifications and methods of inspection for all aircraft requirements for the two services.

GROUND SCHOOLS FOR AVIATORS.

Supplementing the recommendations made to the Secretary of War and to the Secretary of the Navy that a continuing program be approved for the production of aircraft, on April 13 the committee recommended to the Council of National Defense that the several problems connected with the establishing of cadet training schools for aviators and with the production of aircraft should be considered together as interrelated problems and should also be considered jointly for the uses both of the Army and Navy.

The committee further, at the suggestion of and in cooperation with the War Department, took the initiative in organizing the several ground or cadet schools for the preliminary training of aviators in this country, and in determining the curriculum and methods of carrying on this instruction.

To this end the committee took under consideration the different methods of training used by Great Britain and France. A special commission was sent to Canada to study the methods of training used at the Camp Borden Military School of Aeronautics at Toronto. The committee called into conference representatives of the War Department, and of six established engineering schools in the United States in connection with the organization of this work. On recommendation of the committee the War Department selected the following six colleges for the establishment of ground-school training in aeronautics: Massachusetts Institute of Technology, Cornell University, Ohio State University, Illinois University, University of Texas, and University of California. Later Princeton University and Georgia School of Technology were added. After the desired organization

and program of training had gained preliminary form, the work of further development and routine supervision was taken over by the War Department.

NAMING OF FLYING FIELDS.

In May, 1917, the committee suggested to the Secretary of War that flying fields be named in commemoration of individuals who had rendered conspicuous service or contributed to the development of aeronautics, and recommended that the aviation schools established near Dayton, Ohio; Champaign, Ill.; and Detroit, Mich., be named in honor of Wilbur Wright, Octave Chanute, and Lieut. Selfridge, respectively.

DEPARTMENT OF AERONAUTICS.

In connection with the consideration of a bill before Congress for the establishment of a separate department of aeronautics, the War Department, under date of May 16, 1917, asked the committee for a recommendation in the matter. The question was considered at the next meeting of the executive committee, and it was recorded as the sense of the meeting that all parties and governmental agencies connected with the development of the air service of the Nation were cooperating in an efficient manner, and that nothing could be gained by the establishment of a department of aeronautics at that time.

AERONAUTIC PATENTS.

In January, 1917, the War and Navy Departments called the attention of the Advisory Committee to the prohibitive prices of aircraft charged by the various aircraft manufacturers, attributing these prices to the extra item of royalty added by each firm in anticipation of infringement suits by owners of alleged basic aeronautic patents who were then threatening all other airplane and seaplane manufacturers with such suits, and causing thereby a general demoralization of the entire industry. After numerous meetings with Government officials, owners of patents, and aircraft manufacturers, extending over a period of several months, the committee recommended the organization of an association among aircraft manufacturers for the purpose of cross-licensing aeronautic patents between the members, such association to be known as the Manufacturers Aircraft Association. The committee cooperated also actively in the determination of the general terms and conditions of this agreement and in securing its adoption by the leading aircraft manufacturers of the country. The question of the legality of this association under the antitrust statutes of the United States having been raised by the Aeronautical Society of America, the matter was submitted by the Secretary of War to the Attorney General of the United States for his opinion. Under date of October 6, 1917, the Attorney General rendered an opinion "that the association (incorporated), as now constituted, and the cross-license agreement under which it is now operated, are not in contravention of the antitrust laws of the United States." The purposes in view in the formation of this association and which it is believed have been achieved, are the following:

(1) The prevention of the virtual deadlock with danger of monopoly existing under the patent situation as obtaining previous to its consummation, and the removal of restraint upon the trade operative under the existence of this patent situation.

(2) The settling or avoiding of all litigation, actual and prospective, under the previously existing patent situation.

(3) The opening of the industry to free competition of all airplane manufacturers and the opening of all patents held by the membership of the association to equal use and on equal terms.

(4) Provision, as set forth in the articles of agreement, whereby a design originating with a given manufacturer may be put into production and used by another manufacturer with all design data, drawings, specifications, etc., on the payment of a small fee, thus facilitating quantity production of an approved design and stimulating the production of new designs or processes.

(5) The development of financial stability and confidence in the airplane industry, thus making possible the financing of the absolutely needed expansion in order to take care of the expected demands.

(6) Reduced cost of aircraft to the Government by reduction of airplane royalties payable under all patents made available under the association to an amount less than one-half the figures previously demanded under a part only of these patents.

(7) Broadly speaking, the encouragement of airplane production to the highest practicable degree and with reference to the demands of the Government under war conditions.

INFORMATION FROM EUROPE.

In March, 1917, the committee arranged, in conjunction with the National Research Council, for representation on the foreign committee sent abroad by the National Research Council to obtain detailed information on scientific matters of importance in connection with the war, and Dr. J. S. Ames, member of this committee, was appointed such representative.

ASSOCIATE MEMBERS.

In order to further develop contact with sources of information from abroad, Lieut. Col. L. W. H. Rees, R. F. C., a member of the British commission, together with Maj. Joseph Tulasne, Capt. Armand de Guiche, and Capt. Amaury de La Grange, of the French Flying Corps and members of the French commission, were made associate members of the committee, and as such attended its meetings, contributing valuable information and suggestions regarding matters with which they were especially familiar.

SAMPLE FORMS OF AIRPLANES FROM EUROPE.

In connection with the bringing of sample forms of airplanes from Europe for use in developing new designs in the United States, the committee cooperated with the War Department in the search for a site and in arranging for the construction of a suitable building.

SITE FOR EXPERIMENTAL LABORATORY.

In October, 1916, the committee took under consideration the question of the selection of a suitable site for the committee's proposed experimental laboratory. In this study the committee acted in cooperation with a board of officers of the United States Army which had been appointed to inspect sites for the experiment station and proving ground of the War Department.

At the suggestion of the War Department requesting recommendation by the Advisory Committee in the matter, this committee inspected several proposed sites and after making inquiries as to the general health conditions and the problems of accessibility to Washington and the larger industrial centers of the East, protection from naval attack, climatic conditions, and cost of the site, it made recommendation to the War Department for the purchase of a site about 4 miles north of Hampton, Va., which recommendation was accepted by the War Department and the site was purchased.

On this field the War Department has allotted to the committee a space suited to the erection of the committee's proposed research laboratories. The committee has designed the first building of the group contemplated, and the design has been approved by the architects for the War Department. Contract has been entered into for the erection of the laboratory at an estimated cost of \$80,900. The laboratory building is now in the course of construction. At this laboratory the committee will carry on, in wide variety, research and investigation relating to aeronautic science and including a study of planes in free flight. The committee has also under preparation plans for the first aerodynamic laboratory to be installed at Langley Field, intended for the development of high wind speeds. The work on this laboratory will be begun as soon as plans are ready.

INSURANCE FOR AVIATORS.

In the early part of the year 1917 the committee took up the question of insurance for aviators, and after correspondence with various life and accident insurance companies in the United States, it suggested to Congress, the War, Treasury, and Navy Departments the advisability of undertaking at an early date the insurance of aviators or some form of financial cooperation with the insurance companies that would enable them to write insurance at rates possible to the insured.

AIRPLANE DESIGN—AIRPLANE MATERIALS—STEEL FOR AIRPLANE CONSTRUCTION.

The committee has cooperated with the Aircraft Production Board in connection with a wide variety of problems relating to the design, specifications, and tests of aircraft. The committee has now in hand (November, 1917) a most important investigation on the use of steel for airplane construction and is supervising the development of a design for construction in steel, to be later subject to a program of tests intended to show the possibilities of such type of construction.

In connection with the subject of the materials for airplane construction, the committee has given its attention chiefly to the investigation of strut forms for airplanes, the strength of spruce spars, and

the development of cotton airplane fabrics as a substitute for Irish linen.

In the field of power-plant design and construction for aircraft, the committee has cooperated with the Bureau of Standards in the design, construction, equipment, and operation of a large vacuum chamber engine testing laboratory which is intended to reproduce the conditions of aeronautic engines operating at high altitudes. This equipment has been installed with special reference to the development and improvement of the "Liberty" engine and important investigations bearing on this problem are now being carried forward. The committee has also carried on a number of researches on the subject of radiator design and proportion, carburetor design and adjustment, ignition apparatus, and is continuing its study of the problem of an airplane engine muffler.

TESTS ON LIBERTY ENGINE.

At the request of the War Department, the committee loaned one of the members of its technical staff for the supervision of tests on the first Liberty engines at Detroit, Pikes Peak, and elsewhere, to determine their mechanical and thermal efficiency and the power delivery of the engines at various altitudes.

AIRPLANE INSTRUMENTS.

The committee has undertaken important investigations relating to the development of various instruments used in the navigation of aircraft and in testing aircraft in free flight. In particular, there has been developed an improved form of geographic position indicator which will be of special value in connection with certain free flight tests under consideration.

AIRCRAFT COMMUNICATIONS.

Regarding the subject of aircraft communications, the committee has cooperated in the development of a generator for wireless sending from airplanes and intended to satisfy the requirements of the Army and Navy. Means for receiving wireless signals in an airplane have also been investigated and it has been established that a very efficient receiving set employing the sound method is practicable; investigations are still being carried on regarding means for detecting hostile airplanes before they are visible or before they can be heard by the unaided ear.

MAPPING FROM AIRPLANES.

On March 8, 1917, the committee took under consideration the development of methods for mapping from airplanes which should be rapid, economical, and sufficiently accurate for aviation purposes. Allotments were made for developing a new type of airplane mapping camera and gratifying progress has been made in the development of such an instrument. Before regular navigation of the air can be undertaken, it will be necessary to supply maps and to establish and suitably mark aerial routes and suitable landing places for the aviator. In certain sections of the country and through the generous

cooperation of patriotic citizens interested in this work, gratifying progress has been made in these directions, notably between Dayton, Ohio, and Rantoul, Ill.

METEOROLOGY AND AERONAUTICS.

In the field of meteorology, the committee recommended to the President an appropriation for the extension of the aerological work of the United States Weather Bureau, and in accordance with which an appropriation of \$100,000 was made by Congress for this work with special reference to the securing of more comprehensive observations on the air in aid of aviation. The committee also acted in cooperation with the United States Weather Bureau in placing meteorological exhibits at the First Pan American Aeronautic Exposition.

In August, 1917, the Advisory Committee recommended that there be organized under the Chief Signal Officer of the Army, as a war measure, a military aerological service with necessary stations and equipment, both in the United States and abroad, and that this service be organized in full cooperation with the Weather Bureau and with care to avoid duplication.

A special report on meteorology and aeronautics has also been prepared and issued as Technical Report No. 13.

BOARD OF WAR INVENTIONS IN AERONAUTICS.

Soon after the declaration of hostilities with Germany the Chief Signal Officer of the Army called to the attention of the committee the large amount of material which was coming before the War Department, comprising inventions and suggestions relating to aeronautics in warfare, and asked assistance in examining and disposing of such material. Accordingly, this committee, through an appropriate subcommittee appointed for the purpose, has acted as a board of inventions for the Government in matters relating to aeronautics, and since the outbreak of hostilities between the United States and Germany it has weekly examined hundreds of suggestions and inventions pertaining to this subject and referred to it by the War and Navy Departments, in addition to the suggestions and inventions which come direct to the committee. This work has required a large amount of time and careful study and has called for considerable increase in the technical and clerical staffs of the committee in order to care for the very large amount of examinations, study, and correspondence with inventors regarding these matters. Several suggestions of value have been received and brought promptly to the attention of the particular Government office most directly interested.

DEFINITION OF TECHNICAL TERMS.

During the year the committee has given further attention to the subject of the definition and standardization of technical terms used in aeronautics, and has prepared a further edition of its bulletin on the subject of nomenclature (Technical Report No. 15).

METRIC SYSTEM FOR DRAWINGS AND CALCULATIONS.

On recommendation of the Advisory Committee, in December, 1916, the War, Treasury, Interior, and Commerce Departments adopted the metric system of weights and measures for all drawings and cal-

culations on aeronautical matters, for use with the accompanying English equivalents. Due to the exigencies of war activities, however, the metric system has not been used generally by the War Department.

AERIAL MAIL ROUTES.

In December, 1916, the subject of cooperation with the Post Office Department in the establishment of aerial mail routes was considered, and the same matter in one form or another has been considered from time to time since that date. Recently the Second Assistant Postmaster General has expressed a desire to develop such routes in a trial way and so far as military requirements may permit furnishing the needed equipment and personnel. The committee is prepared to advise with and aid the Post Office Department in the furtherance of these aims.

CIVIL AERIAL TRANSPORT.

In the latter part of 1917 the general subject of civil aerial transport was brought to the attention of the committee and a special subcommittee was appointed to take under consideration the various phases of civil and commercial uses of aeronautics with special reference to the conditions which may be expected to develop at the close of the war.

LANDING FIELD FOR TRANSIENT AVIATORS.

In connection with the accommodation of transient aviators in Washington, the committee cooperated with the War Department in the selection of a tract of land on the Eastern Branch of the Potomac River and southeast of the Washington Navy Yard.

PRODUCTIVE CAPACITY OF AERONAUTIC INDUSTRY—INSPECTION TRIPS.

During November, 1917, members of the Advisory Committee in two different groups made trips of inspection to the three principal centers of airplane production, namely, Dayton, Ohio; Detroit, Mich.; and Buffalo, N. Y.

The purpose of these trips was to place the committee in immediate contact with the conditions in the industrial field and give them an opportunity of forming a personal, first-hand judgment regarding the productive capacity for airplanes and for aeronautic engines as provided by the facilities developed at that date, and as contemplated in plans for further development.

The members of the committee have been very favorably impressed with the serious energy and purpose with which the manufacturers are approaching the problem of the quantity production of aircraft and aircraft engines, and with the productive capacity which is now rapidly approaching the point of effective service. Counting on a similar spirit and purpose throughout the field of aircraft industry, there seems every reason to anticipate productive capacity adequate to meet the needs of the Government.

TECHNICAL REPORTS.

The first annual report of the committee contained technical reports Nos. 1 to 7, and the second annual report Nos. 8 to 12. With this, the third annual report, the committee submits technical reports Nos. 13 to 23, as follows:

Report No. 13, entitled "Meteorology and Aeronautics," was prepared by Prof. William R. Blair, in charge of aerological investigations, United States Weather Bureau, and submitted through the subcommittee on the relation of the atmosphere to aeronautics. This report discusses problems and general phenomena of the atmosphere. On request of the Signal Corps, it has been printed as a separate document by the committee for widespread distribution, as it contains information of special value to all aviators and aeronauts.

Report No. 14, entitled "Experimental Research on Air Propellers," was prepared and submitted by Dr. William F. Durand, chairman of the National Advisory Committee for Aeronautics. A brief description of this report is contained under "General problems and activities," paragraph E. It has been printed by the committee as a separate document for immediate distribution in order to supply much-needed information at the earliest moment to those who are interested in the design of air propellers.

Report No. 15, entitled "Nomenclature for Aeronautics," was prepared and submitted by the subcommittee on nomenclature for aeronautics, of which Dr. Joseph S. Ames is chairman. It has been printed by the committee as a separate pamphlet.

Report No. 16, entitled "The Stretching of the Fabric and Deformation of the Hull in Full Balloons," is a translation from the German, by Prof. Karl K. Darrow, of the University of Chicago.

Report No. 17, entitled "An Investigation of the Elements which Contribute to Statical and Dynamical Stability and of the Effect of Variation in those Elements," was prepared by Prof. Alexander Klemin, of the Massachusetts Institute of Technology, under contract entered into by the committee with Prof. C. H. Peabody, of the same institution.

Report No. 18, entitled "Aerofoils and Aerofoil Structural Combinations," is a graduating thesis prepared at the Massachusetts Institute of Technology by Maj. H. S. Martin, S. C., and Maj. E. S. Gorrell, S. C., and has been included in the present report by the committee on account of the importance of the information which it contains.

Report No. 19, entitled "Periodic Stresses in Gyroscopic Bodies with Applications to Air Screws," was prepared and submitted by Dr. A. F. Zahm of the Washington Navy Yard.

Report No. 20, entitled "Aerodynamic Coefficients and Transformation Tables," was prepared by the committee under direction of Dr. Joseph S. Ames, member.

Report No. 21, entitled "Theory of an Airplane Encountering Gusts, II," was presented as a paper before the American Philosophical Society by Prof. E. B. Wilson, of the Massachusetts Institute of Technology, being a continuation of a report on the same subject printed in the first annual report of the committee. For this reason and in order to complete the treatment of the subject in the records of the committee this paper is included in the present report.

Report No. 22, entitled "Fabrics for Aeronautic Construction," was prepared by Mr. E. D. Walen, of the United States Bureau of Standards, and submitted through the subcommittee on standardization and investigation of materials. This report consists of two parts, the first dealing with cotton fabrics intended for the covering of airplane wings and the second with balloon fabrics.

Report No. 23, entitled "Aeronautic Power-Plant Investigations," was prepared by Dr. H. C. Dickinson, of the United States Bureau of Standards, and submitted through the subcommittee on power plants. This report consists of three parts. The first, entitled "Performance of Aeronautic Engines at High Altitudes," gives a description of the construction and equipment of a special testing laboratory intended to furnish, under control, the operating conditions of an aeronautic engine at high altitudes and under any desired conditions of air density, temperature, and humidity. Part 2, entitled "Radiator Design," gives a description of special apparatus designed and constructed for the investigation of different types of radiator sections and with a view to the development of the better knowledge of the interrelation among the various factors entering into radiator performance. Part 3, entitled "Spark Plugs," gives a description of a series of tests on different types and forms of spark plugs and of measurements intended to indicate the relation between the various factors affecting performance of the same.

GENERAL PROBLEMS AND ACTIVITIES.

The general problems enumerated in the preceding annual reports of the committee constituted the program of work during the past year. Progress has been made in the scientific study and solution of these problems which are considered of immediate importance, and they will be attacked on a larger scale by the committee with the increased facilities which will be available on completion of the committee's research laboratory at Langley Field.

A. Stability as determined by mathematical investigations.—The literature on this subject has been augmented by a report (No. 21) entitled "Theory of an Airplane Encountering Gusts, II," prepared by Prof. E. B. Wilson, of the Massachusetts Institute of Technology, in continuation of his report on the same subject contained in the first annual report of this committee.

Report No. 17, entitled "An Investigation of the Elements which Contribute to Statical and Dynamical Stability and of the Effects of Variation in Those Elements," contains valuable information from the standpoint of inherent stability, and also gives data on static longitudinal balance heretofore unavailable to the designing engineer.

B. Air-speed meters.—The complete air-speed meter involves an indicating instrument and a head for the production of pressure difference, which may be either a Pitot or Venturi tube or a combination of the two. The French use almost entirely the Venturi-Pitot; the English, the Pitot with accompanying static tube. With a view to diminishing the danger of clogging the tube with water, Dr. A. F. Zahm, of the Washington Navy Yard, has inverted the mount on the Venturi-Pitot combination so that draining is more certain, and also used a larger cross-section of throat and connecting tubes than has been common abroad. This tube gives a difference of pressure almost exactly proportional to the square of the speed, and though considerably heavier than the English Pitot tube, it permits of the use of a more rugged indicating instrument. The recently improved Foxboro indicating instrument is considerably reduced in size and behaves very well under the trying conditions of vibration experienced on an airplane, but the scale is very far

from uniform. The production of a uniform scale is the next improvement to be desired, and development is being pushed with several types. Maj. C. E. Mendenhall, a member of the subcommittee on instruments, has in hand a large number of problems.

C. *Wing sections*.—Several aerofoil sections designed by officers of the Signal Corps and tested in the Massachusetts Institute of Technology wind tunnel give promising results. A description of these aerofoils and the data obtained from the tests are embodied in Report No. 18.

D. *Engines*.—The most notable development in aeronautic engines in America during the past year has been the Liberty engine, designed under the direction of the Aircraft Production Board and embodying the best American ideas in combination with information from Europe regarding the best foreign designs, and made available during the early summer of 1917.

D-1. The manufacture of the Hispano-Suiza engine has been successfully developed in the United States during the past year, and certain other engines of foreign design have been likewise modified with reference to economical quantity production by American manufacturers.

D-2. An experimental study of the fundamental principles of radiator design, with particular reference to the effect of air velocity and density on the cooling capacity of various possible types of cellular construction, was undertaken in May, 1917. For the purposes of this investigation, a comprehensible experimental plant has been constructed at the Bureau of Standards and specimen radiators have been obtained from most of the manufacturers of automobile as well as aeronautic radiators. This group of specimens includes not only a wide variety of types of construction, but several series of specimens differing in one respect only, as for instance, cell length. Measurements are being made for this group of specimens of the cooling capacity, head resistance, weight, water capacity, resistance to water flow, air cell dimensions, etc.

D-3. During the present year suitable testing equipment has been installed at the Bureau of Standards for the carrying on of an extended experimental program on aircraft engine performance with special reference to high altitude conditions. The "altitude" laboratory planned for these investigations comprises the following equipment:

A reinforced concrete chamber, in which engines may be run at reduced pressures of below one-half atmosphere; a 300 horsepower dynamometer for absorbing and measuring the power output; an exhaust blower of sufficient capacity to carry off the exhaust from the engines under test and to maintain the reduced pressure in the test chamber; a refrigeration plant for cooling the intake air and the air circulation in the chamber; fans for producing circulation in the test chamber; and equipment for measuring all quantities necessary for a complete record of engine performance.

One of the Liberty engines (eight cylinder) now in place in the test chamber is being studied for the effects of altitude and fuel changes. Following this it is expected that the twelve cylinder model will be studied, then other engines, particularly those especially designed for high altitude flying, will be taken up.

D-4. The study of performance and causes of failure of spark plugs has developed a large number of parallel investigations. The causes of failure are numerous, including mechanical (accidental) breakage, cracking due to thermal expansion, gas leakage under compression, fouling with soot, or carbon deposit, and "cut-out" or short circuiting as the insulator becomes conducting at high temperatures.

The latter, while perhaps not the most common cause of failure, offered the most promise of valuable results from a laboratory investigation, hence the greater share of time has been devoted to it. Satisfactory laboratory methods have been developed for measuring and specifying the relative merits of different types of spark plugs as regards "cut-out."

Reasonably satisfactory methods for testing for gas leakage and liability to breakage from sudden heating have been developed.

Specifications for acceptance tests of spark plugs have been prepared in cooperation with the inspection section of the Signal Corps, and tests under these specifications have been carried on at the Bureau of Standards, where the spark-plug investigation is in progress. These tests include not only laboratory tests, but endurance tests in an engine.

D-5. A method of measuring vapor pressures of gasolines has been developed and the necessary equipment nearly completed. This work is now being carried on at the University of Virginia by a member of the faculty who spent the summer at the Bureau of Standards perfecting the program and building the experimental apparatus.

Work on the latent heats of fuels has only recently been undertaken at the Harvard laboratory, where space and shop facilities are available. Trial apparatus for this work is under construction, but the final design of experimental equipment has not yet been perfected.

E. *Propellers*.—During the year an investigation has been carried out on model propellers, the results of which are given in Report No. 14. A series of model propellers selected for this investigation have been taken with a view of regular distribution among the various properties and characteristics, such as pitch, form of blade, blade width, form of blade section, etc. These tests are intended to form a basis for comparison with experiments carried on in other laboratories, and also with the system of theoretical design now in common use and first enunciated by Drzewiecki. They are also intended to serve as a basis of comparison with coefficients of the performance of full-scale propellers in order to provide much-needed information regarding the relation between model and full-scale experiments. It is a part of the program held in view to test a certain number of full-sized propellers representing a distributed selection of the model forms. The results of such tests will then serve to connect directly the model tests on the corresponding forms with full-sized tests, and, presumably, by extension the coefficients thus developed may be used for the entire series of model experiments.

A further contract has been made with Dr. W. F. Durand, to be carried out at the aerodynamic laboratory at the Leland Stanford, Jr., University, covering a large number of further investigations in the field of air-propeller performance.

F. *Form of airplane*.—During the year there has been carried on at the Massachusetts Institute of Technology on behalf of the com-

mittee an investigation on this subject by Prof. Alexander Klemin, the results of which are published in Report No. 17.

A large amount of experience with full-sized machines in Europe, especially under war conditions, has contributed greatly to a better understanding of this important problem, and in particular much available information has been acquired regarding the factors involved in inherent stability.

G. Radiotelegraphy.—During the year the committee has carried on active work on the subject of radiotelegraphy in cooperation with various other agencies engaged in the study of this problem. The best form of generator for use on airplanes has been given careful study, and it has been developed (a) that 500 cycle alternating current generators, giving 1,000 sparks per second, and of an output of 500 watts can be and have been made, which will satisfy all the requirements of the Army and Navy which were imposed; (b) a vacuum tube oscillator for telephonic communications between airplanes has been developed, giving satisfactory results.

The problem of receiving wireless signals has also been investigated and it has been established that a very efficient receiving set employing the sound method is practicable. The question of detecting and locating hostile airplanes or airships before they are seen, or heard by the unaided ear, has also been investigated, but without thus far fully satisfactory results.

H. Bibliography of aeronautics.—A bibliography of aeronautics was published by the Smithsonian Institution in 1909. The committee has well in hand the extension of this work up to January, 1917, and it will be published as soon as completed.

PHYSICAL PROBLEMS.

Beside the more general problems, the following problems of a physical, rather than an aeronautical nature, are of particular interest, and under same the following progress is noted.

A. Noncorrosive materials.—For the protection of iron and steel, investigations of zinc coatings produced by the hot dip, sherardizing, and electroplating processes have been carried on at the Bureau of Standards. Investigations are under way to determine the relative resistance to corrosion by these processes and also the effect on the physical properties of steel as influenced by such processes. Various methods of testing these products as by accelerated tests, such as the salt-spray test, measurements of thickness and quantity of coating are being studied to develop adequate specifications for these materials.

Some work has also been done in connection with the following additional rust-proof processes: Copper and nickel plating; Parker process (which consists in treating with phosphoric acid and final oiling); the magnetic oxide coating such as Bon Tempi process, which may or may not be oiled; lead coating as produced by the Lohman hot-dip process; tin coating; metallic coatings produced by the metal-spraying process; inert coating, such as paint, japan, and baked enamels.

The great variation in thickness and weight of the metallic coatings produced under commercial conditions are such as to make it difficult if not impossible, to determine their value by these measurements

alone. Some standard accelerated corrosion tests are therefore necessary before uniformly protected coatings can be specified.

B. *Flat and cambered surfaces.*—The committee has obtained reports of several tests conducted at the National Physical Laboratory of Great Britain, which contain valuable information on stabilizers, elevators, and rudders.

Accurate data can be obtained from Report No. 17, previously referred to, as to variations to be made in tail surfaces, viz: size; position, both longitudinal and vertical; angles of tail plane to wing; aspect ratio; and sections, flat and cambered.

C. *Terminal connections.*—Tests have been made on two forms of terminal connection, one a sleeve allowing the forming of a solderless loop and the other a turnbuckle by means of which a cable or wire may be loosened without unscrewing the turnbuckle barrel. The tests thus far are not wholly conclusive as to the special value of these connections, and further tests are contemplated.

D. *Characteristics of constructive materials.*—A number of tests on materials entering into airplane construction have been made, and in particular satisfactory progress is reported in the development of a cotton substitute for linen airplane fabric. (See Report No. 22, pt. 1.) An extended investigation has also been carried on relating to the physical characteristics of balloon fabrics and with special reference to the factors which enter into the strength, durability, and gas-tightness of such fabrics. Specifications for balloon fabrics have been furnished to the Army and Navy covering fabrics of the same general type as are now being used, and with the addition of certain refinements relating to uniformity of construction and finish considered from the viewpoint of the influence of the fabric on the gas-retaining properties of the rubber film. (See Report No. 22, pt. 2.) A considerable amount of experimental work has also been carried on in connection with the physical properties of light alloys adapted to aeronautic construction, and also types of alloy steel. This investigation is continuing, and report in detail is not available for inclusion in this report.

E. *Generation of hydrogen.*—Satisfactory progress of a confidential nature has been made by the Bureau of Steam Engineering of the Navy Department in connection with the installation of hydrogen plants aboard ships.

F. *Standardization of specifications for materials.*—The Joint Army and Navy Technical Board, which was organized on recommendation of the Advisory Committee, is engaged with this problem, and substantial progress has been made.

The International Aircraft Standards Committee, with which this committee is working in full cooperation, is also actively engaged in the work of developing satisfactory standards for international adoption at the forthcoming conference to be held in London, and definite progress is anticipated along these important lines.

FINANCIAL REPORT.

The appropriation "Advisory Committee for Aeronautics, 1917," carried in the naval appropriation act approved August 29, 1916, is as follows:

For traveling expenses of members and employees, \$2,000; two technical assistants, at \$2,500 each; one clerk, at \$1,500; one clerk, at \$1,000; one draftsman, at \$2,000; one draftsman, at \$1,000; two laborers, at \$660 each; three mechanics, at \$1,200 each; rent of office, \$1,200; supplies, \$7,800; special reports, \$5,000; movable combination field office, machine shop, dynamometer shed, hangar, and power plant, \$15,000; dynamometer carriage and truck, \$18,000; aeroplane, including motor, \$10,000; transmission dynamometer, \$1,000; ripograph, \$1,000; stabilizer, \$1,500; anemometers, barographs, inclinometers, incidence indicators, \$1,500; miscellaneous supplies, spare parts for operation of field plant, \$5,580; in all, \$85,000.

The amount carried in the appropriation act was \$85,000, but on account of the late passage of the act, only \$82,515.70 was warranted by the Treasury Department. This sum, added to the continuing appropriation of \$5,000 a year for five years carried in the act establishing the committee, made a total of \$87,515.70 available for the fiscal year 1917.

The naval act making appropriations for the fiscal year 1918, approved March 4, 1917, provided that the balances then remaining under the several items of the appropriation for 1917 be consolidated into a single fund and made available for the purposes stated in the act establishing the committee.

Out of this total appropriation of \$87,515.70 for the expenses of the committee for the fiscal year 1917, the committee reports expenditures and obligations during the year amounting to the total of the appropriation, itemized as follows:

Expenditures and obligations incurred under the appropriation "Advisory Committee for Aeronautics, 1917."

Traveling expenses.....	\$2,389.82
Employees (clerical and technical).....	3,779.17
Rent of office.....	1,200.00
Printing.....	1,136.78
Furniture and equipment.....	1,307.83
Stationery.....	351.23
Telephone service.....	104.81
Telegrams.....	72.42
Books and magazines.....	153.11
Development of airplane mapping camera.....	963.10
Special reports:	
Experimental research on air propellers.....	\$4,000.00
Bibliography of aeronautics.....	3,000.00
Aerodynamic coefficients and transformation tables.....	100.00
	7,100.00
Construction of research laboratory.....	68,957.35
	<hr/> 87,515.70

APPROPRIATION FOR THE FISCAL YEAR 1918.

The appropriation "National Advisory Committee for Aeronautics, 1917-18" carried in the naval appropriation act approved March 3, 1917, is as follows:

For scientific research, technical investigation, and special reports in the field of aeronautics including the necessary laboratory and technical assistants; traveling expenses of members and employees; rent (office in the District of Columbia, not to exceed \$1,500); office supplies, printing and other miscellaneous expenses; clerks; draftsmen; personal services in the field and in the District of Columbia: *Provided*, That the sums to be paid out of this appropriation for clerical, drafting, watchmen and messenger service for the fiscal year ending June 30, 1918, shall not exceed \$12,000; in all, \$107,000.

This appropriation became immediately available upon the passage of the act, and, added to the continuing appropriation of \$5,000 a year for five years, carried in the act establishing the committee, made a total of \$112,000 available for the fiscal year 1918.

In order to provide funds for the completion of the committee's research laboratory, the following amendment to the above appropriation was contained in the urgent deficiency act approved October 6, 1917:

National Advisory Committee for Aeronautics: Such portion of the appropriation "National Advisory Committee for Aeronautics" carried in the act making appropriations for the Naval Service for the fiscal year ending June thirtieth, nineteen hundred and eighteen, approved March fourth, nineteen hundred and seventeen, as may be necessary, not to exceed \$40,000, is made available for the completion of the committee's research laboratory now under construction, and for the construction of additional buildings necessary in connection therewith.

ESTIMATES FOR THE FISCAL YEAR 1919.

The following estimates of expenses for the fiscal year 1919 have been submitted by the committee in due form:

For scientific research, technical investigations, and special reports in the field of aeronautics, including the necessary laboratory and technical assistants, traveling expenses of members and employees, rent of offices in the District of Columbia, office supplies, printing, and other miscellaneous expenses, equipment, maintenance, and operation of research laboratory, and construction of additional buildings necessary in connection therewith; purchase, maintenance, operation, and exchange of necessary airplanes and one motor-propelled, passenger-carrying vehicle; clerks; draftsmen; personal services in the field and in the District of Columbia: *Provided*, That the sum to be paid out of this appropriation for clerical, drafting, watchmen, and messenger service for the fiscal year ending June thirtieth, nineteen hundred and nineteen, shall not exceed \$20,000; in all, \$260,000.

CONCLUSION.

In conclusion attention is invited to the following:

1. The committee has been in existence about two and one-half years and during that time has carried through and prepared for publication 23 technical reports dealing with various phases of the science and art of aeronautics. It has further been occupied in the design and construction of its first laboratory units at Langley Field, which will be ready for occupancy early in 1918. It has further occupied itself with a great variety of questions relating to the preparations for war and with the various activities which have sprung up as a result of the existing state of war.

2. The plans contemplated for the coming year include:

(a) A continuance of the manifold miscellaneous activities resulting from the existing state of war.

(b) The completion of the first laboratory units at Langley Field and the installation of the necessary apparatus and equipment.

(c) The organization of a small scientific staff and the investigation of many important problems relating to the science and art of aeronautics, and with a view to their practical solution and application to the present war demands.

3. The preceding years of the committee's activities must therefore be viewed in some degree as preparatory for the more effective service which the committee hopes to render through its laboratory facilities

at Langley Field and through the enlarged technical and scientific staff contemplated in connection therewith.

4. The committee trusts that these opportunities for enlarged service, and with special reference to the present war conditions, may be found an adequate justification for the appropriation herein requested.

Respectfully submitted.

W. F. DURAND, *Chairman.*

TECHNICAL REPORTS
OF THE
NATIONAL ADVISORY COMMITTEE FOR
AERONAUTICS .

REPORTS 13 TO 23